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(54) A VEHICLE FOR CLIMBING STAIRS

(71) I, JOHN FAY FLEMING, a citizen of the United States of America, of 1191 Del Mar Parkway, Aurora, County of Arapahoe, State of Colorado, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a vehicle for climbing stairs.

According to the invention there is provided a vehicle for climbing stairs comprising a frame, an axle rotatably mounted on the frame and having end portions extending outwardly therefrom, a motor for driving said axle, a multiple-armed spider rotatably mounted on each outer end portion of the axle, a wheel rotatably mounted on each arm adjacent the outer end thereof, all of the wheels on each spider being so connected that rotation of one wheel on a spider will cause the remaining wheels on that spider to rotate in unison and, means coupling one of said wheels on each spider with the axle, the arrangement being such that the axle is operable to rotate a said spider, when one of the wheels thereon is restrained against rotation.

Further according to the invention, there is provided a vehicle for climbing stairs comprising a body member, a multiple-armed spider rotatably mounted on opposed sides of the body member, a wheel mounted on each spider arm at or adjacent the outer end thereof, the wheels on each spider being rotatably connected such that rotation of one of the wheels of the spider causes rotation of the other wheels on the spider, first rotatable means rotatable co-axially relative to one spider, second rotatable means rotatable co-axially relative to the other spider, drive means for driving said first and second rotatable means, means rotatably connecting said first rotatable means with one of the wheels on said one spider to rotate the wheels on said one spider in the same rotational sense as said first rotatable means, and means rotatably connecting said second rotatable means with one of the wheels on said other spider to rotate the wheels on said other spider in the same rotational sense as said second rotatable means, the arrangement being such that each said rotatable means is operable to drive its associated spider when one of the wheels thereon is restrained against rotation.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a side elevation of a stair climbing vehicle embodying the present invention:

Figure 2 is a bottom plan of the vehicle shown in Figure 1 with portions of the frame omitted;

Figure 3 is a section to an enlarged scale taken on line 3—3 of Figure 2;

Figure 4 is a section to an enlarged scale taken on line 4—4 of Figure 2;

Figure 5 is a side elevation of the vehicle in the climbing position with portions of the frame omitted;

Figure 6 is a diagrammatic view of the wheels and force vectors of the vehicle in four different positions identified by A, B, C and D during its horizontal and vertical transition; and

Figure 7 is a diagrammatic view of the wheels and force vectors of the vehicle while moving along a slight incline.

Referring now to the drawings for a detailed description of the invention and, more specifically, to Figures 1 and 2 for this purpose, it will be seen that the stair climbing vehicle has been designated in its entirety by reference numeral 10. The frame or body 12 may vary widely in form and construction. In the preferred form illustrated, the frame is shown having longitudinal side members 14 terminating at their upper ends in hand grips 16. The side members 14 are connected by a cross member 18 and a base plate 20 to form a rigid rectangular structure. The member 18 is positioned at the lower end of the frame and has an upwardly extending flange 22 which provides a load carrying lip for the object being transported. At the lower

[Price 5s. 0d. (25p)]

extremities of the side members 14 is a widened portion 24 which provides a mounting base for a primary axle 26.

Mounted on the frame adjacent the hand grips 16 is a mechanical hand lever 28. The lever operates a set of brakes 30 which will later be described in detail in conjunction with the operation of the vehicle.

The vehicle 10 is supported by the primary axle 26 which is attached to the side members 14 and plate 20 by a set of journal bearings 32, thereby allowing the axle to freely rotate therein (as seen in Figure 2). Positioned at each end of the axle 26 are a pair of spiders 34 having radially extending arms 35. In the particular form of the invention illustrated, each spider has three arms 35. Rotatably journaled at the outer end of each arm 35 is a rubber-tired wheel 36. Each wheel 36 is mounted on a secondary axle 38 which is in turn journaled at each end in bearings 40. Integrally mounted on axles 38 in concentric juxtaposed relation with the wheels 36 are a plurality of drive sprockets 42. The sprockets 42 on each spider 34 are connected by a common drive chain 44 as seen in Figure 4. The chain 44 passes behind a series of idler sprockets 46 so as to keep the chain from contacting the edge of the step during the rotation of the spider. By reason of chain 44, all of the wheels 36 on each spider must rotate together at the same speed. Concentrically positioned on the opposite end of one of the axles 38 in each spider is an additional small sprocket 48, as seen in Figure 3. Small sprocket 48 is driven by a larger drive sprocket 50 through a drive chain 52. Sprocket 50 is integrally mounted on the primary axle 26 by key 53. It will be appreciated that the sprocket 48, and hence the wheels 36, will be driven in the same rotational sense as the axle 26. Journal bearings 54, which are mounted in the center of the spiders 34, are freely rotatable on the outer ends of the axle 26 (as seen in Figure 2).

Primary axle 26 drives the wheels 36 and spider 34 which are connected by an epicyclic drive as just mentioned above. Power is applied to axle 26 through a common differential gear box 56 and a reversible motor 58. Although an electric motor 58 is illustrated, any type power source could be used. The motor 58 transfers its energy to the differential 56 by way of clutch 59, sprocket 60, chain 62 and sprocket 64, as seen in Figure 2. The energy applied to the primary axle 26 can be controlled in a variety of ways. For example, the clutch 59, which could be magnetic or mechanical, would be always left engaged. The movement of the vehicle would thereby be controlled by merely turning the motor switch on or off. The drag of the motor 58 would provide adequate braking in the absence of brakes 30. Another way to control the vehicle 10 would be by connecting the hand brake lever 28 to a switch or linkage which would disengage the clutch 59. In a control of this type, the clutch would disengage and, at the same time, the brakes would be applied.

Operation

In operating the vehicle 10, the power source 58 is activated, whereby mechanical energy is passed through the differential to the primary axle 26. Sprockets 50 mounted on axle 26 in turn transfer the torque to one wheel on each spider by way of chains 52. Since all of the wheels on each spider are connected by chain 44, they will all move accordingly. When the wheels 36 come in contact with a step as seen in Figure 5, the moment necessary to turn the wheels increases until it exceeds the moment needed to rotate the spider. Since the wheels cannot move, the torque supplied to sprocket 48 causes the spider 34 to rotate about the axle 26 while a constant torque is maintained on the load bearing wheel 36.

The various moments and forces acting upon the vehicle 10 at various times during its climbing cycle are illustrated in diagrammatic form in Figures 6 and 7, which will now be described in detail.

Position A (Figure 6)

When the vehicle is moving across an unobstructed horizontal surface, the forces effecting the wheels and spider of the vehicle are as shown in Position A in Figure 6. The weight W carried by the vehicle is substantially acting at the center of the spider in a vertical direction. The moment necessary to horizontally move the vehicle is a resistance force R (acting at the point of contact of the wheel in a horizontal direction) multiplied by the radius of the wheel y which is represented by the moment Ry. Of course, the torque supplied from the motor 58 to the wheels would always exceed the moment Ry necessary to move the vehicle. As long as the surface being traversed remains essentially flat, the moment Ry will not change except for minor variances caused by variable loads carried by the vehicle 10.

Position B (Figure 6)

When the forward wheel comes in contact with the first stair riser, the moment needed to turn the wheels substantially increases. The moment necessary to rotate the spider is the weight of the load W multiplied by the moment arm x, which is illustrated in the drawings. As soon as the motor torque applied to the wheels exceeds Wx, the spider will begin to rotate and climb the first step. Once the spider begins to rotate, the moment arm x decreases, thereby causing the spider moment to decrease. As the load W passes over the centre of the load bearing wheel, the spider moment becomes zero and load W acts in a sense to drive the motor. Until the second wheel comes in contact with the next tread, the motor acts as a brake. Although the spider moment Wx is greater than the necessary rolling moment Ry, it is less than the frictional moments

$(F_{1y} + F_{2y})$ needed to slide or skid the wheels on their respective bearing surfaces. If this were not the case, the spider would not rotate but would merely spin its wheels when contact was made with a vertical obstruction.

POSITION C (Figure 6)

Once the spider has climbed the first tread, the continuous torque on the wheels will cause them to move forward until contact is made with the second step (Position D). Once the riser is contacted, the previously mentioned cycle is repeated as the spider climbs the next step.

The spider moment Wx is predetermined by the spacing between the wheels on the spider. The greater the spacing, the greater is the moment arm x. The spider moment Wx is sufficiently greater than the rolling moment Ry so that the spider will not accidentally rotate when the wheels contact a minor obstruction or traverse a slight incline as shown in Figure 7. The rolling moment necessary in Figure 7 would be R_1,($R_1 = R + W_h$) which is greater than Ry, but still less than the spider moment Wx.

When the vehicle contacts a stair or an angle so that the wheels on one side contact before those on the other, the differential 56 allows the vehicle to square with the stair before the spiders begin to rotate. Otherwise, the spiders 34 on each side of the vehicle would be separately rotating at different times, which would provide a dangerous situation. When it is desirous to guide the vehicle around a curve, the situation arises where the increased drag on the inside wheel could cause the one spider 34 to rotate in the absence of a differential.

WHAT I CLAIM IS:—

1. A vehicle for climbing stairs comprising a frame, an axle rotatably mounted on the frame and having end portions extending outwardly therefrom, a motor for driving said axle, a multiple-armed spider rotatably mounted on each outer end portion of the axle, a wheel rotatably mounted on each arm adjacent the outer end thereof, all of the wheels on each spider being so connected that rotation of one wheel on a spider will cause the remaining wheels on that spider to rotate in unison and, means coupling one of said wheels on each spider with the axle, the arrangement being such that the axle is operable to rotate a said spider when one of the wheels thereon is restrained against rotation.

2. A vehicle according to claim 1 wherein the wheels are positioned on the arms of the spider a sufficient distance from the centre of rotation of the spider whereby the torque necessary to rotate the spider is higher than that needed to rotate the wheels and move the vehicle along a horizontal surface.

3. A vehicle according to claim 1 or claim 2 wherein the coupling means comprises an endless chain rotatably connecting a first sprocket mounted for rotation with the axle, and a second sprocket mounted for rotation with said one wheel.

4. A vehicle according to any one of the preceding claims wherein the said axle comprises two separate sections connected by a differential gear whereby the wheels on one spider can move independently of the wheels on the other spider.

5. A vehicle according to any one of the preceding claims wherein said axle is drivable by said motor via a clutch.

6. A vehicle according to claim 5 including a brake for arresting rotation of the axle, and control means arranged to activate the brake simultaneously with the disengagement of said clutch.

7. A vehicle according to any one of the preceding claims wherein the wheels have a diameter such that as the vehicle climbs the stairs contact is made only with the wheels.

8. A vehicle according to any one of the preceding claims wherein each wheel includes sprocket means mounted for rotation therewith, the sprocket means on each spider being connected by an endless chain.

9. A vehicle for climbing stairs comprising a body member, a multiple-armed spider rotatably mounted on opposed sides of the body member, a wheel mounted on each spider arm at or adjacent the outer end thereof, the wheels on each spider being rotatably connected such that rotation of one of the wheels of the spider causes rotation of the other wheels on the spider, first rotatable means rotatable co-axially relative to one spider, second rotatable means rotatable co-axially relative to the other spider, drive means for driving said first and second rotatable means, means rotatably connecting said first rotatable means with one of the wheels on said one spider to rotate the wheels on said one spider in the same rotational sense as said first rotatable means, and means rotatably connected said second rotatable means with one of the wheels on said other spider to rotate the wheels on said other spider in the same rotational sense as said second rotatable means, the arrangement being such that each said rotatable means is operable to drive its associated spider when one of the wheels thereon is restrained against rotation.

10. A vehicle substantially as hereinbefore described with reference to figures 1 to 5 of the accompanying drawings.

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1213930 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

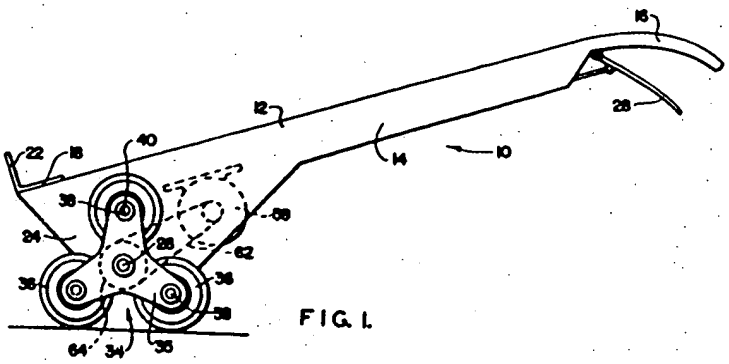

FIG. 1.

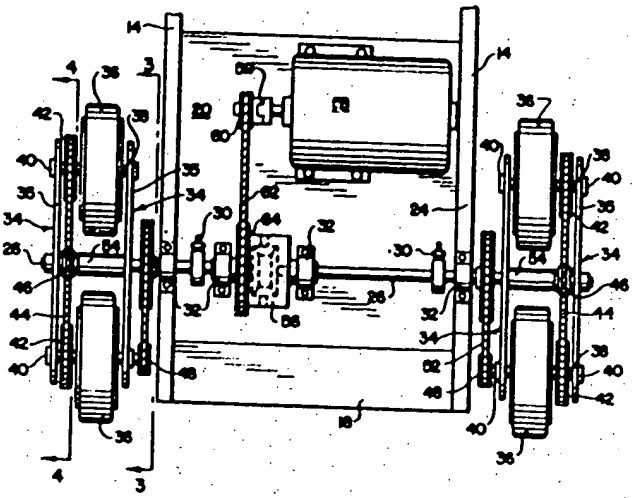

FIG. 2.

1213930 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

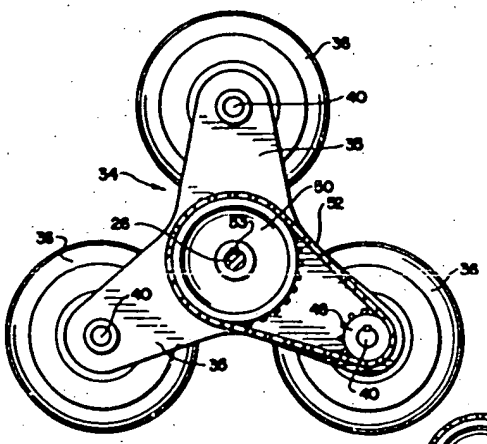

FIG. 3.

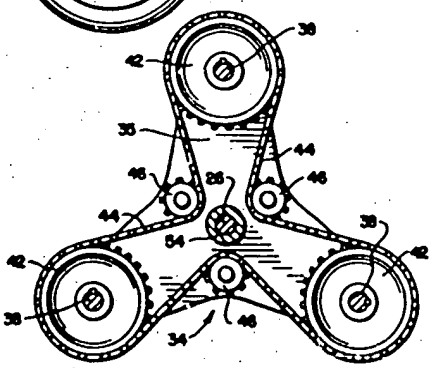

FIG. 4.

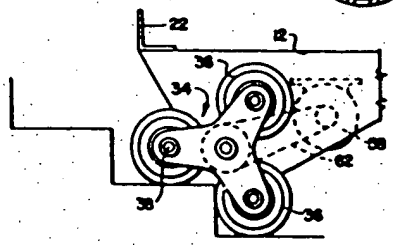

FIG. 5.

1213930 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

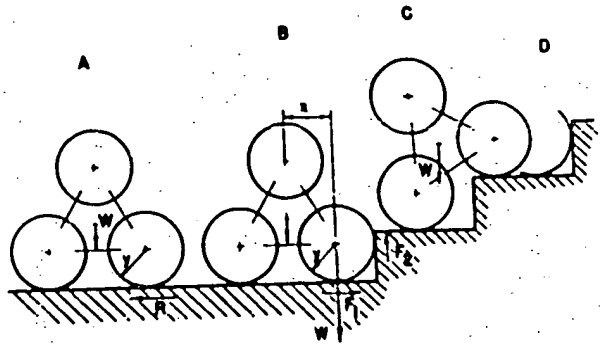

FIG. 6

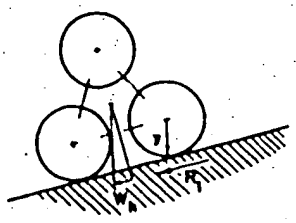

FIG. 7